

Toxic Exposure

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Introduction

There are major space flight emergencies that could have significant medical consequences. These include an onboard fire, cabin depressurization (for example, due to a meteorite hit), and accidental exposure of the crew to toxic chemicals (either liquid or gas). Toxic atmospheric contamination of a spacecraft cabin can lead to metabolic disease and upper respiratory, pulmonary, and ocular injury. Chemicals such as nitrogen tetroxide, hydrazine gas, ammonia, Freon, and many others are used for propulsion, cooling, and in scientific experiments; and chemical and debris toxins are generated from spacecraft fires. Symptoms will depend on the route of exposure and on the specific toxin which was released. In a toxic contamination event, exposure may be mitigated by the use of oxygen or toxin (with filter canister) protective masks and other personal protective equipment such as goggles and gloves. Treatment will vary based on symptoms and type of chemical and may include medical monitoring, oxygen, bronchodilator medications, rinsing the eyes, and providing antidotes.^{[1][2]}

Clinical Priority and Clinical Priority Rationale by Design Reference Mission

One of the inherent properties of space flight is a limitation in available mass, power, and volume within the space craft. These limitations mandate prioritization of what medical equipment and consumables are manifested for the flight, and which medical conditions would be addressed. Therefore, clinical priorities have been assigned to describe which medical conditions will be allocated resources for diagnosis and treatment. “Shall” conditions are those for which diagnostic and treatment capability must be provided, due to a high likelihood of their occurrence and severe consequence if the condition were to occur and no treatment was available. “Should” conditions are those for which diagnostic and treatment capability should be provided if mass/power/volume limitations allow. Conditions were designated as “Not Addressed” if no specific diagnostic and/or treatment capability are expected to be manifested, either due to a very low likelihood of occurrence or other limitations (for example, in medical training, hardware, or consumables) that would preclude treatment. Design Reference Missions (DRMs) are proposed future missions designated by a set of assumptions that encompass parameters such as destination,

length of mission, number of crewmembers, number of Extravehicular Activities (EVAs), and anticipated level of care. The clinical priorities for all medical conditions on the Exploration Medical Condition List (EMCL) can be found here (https://humanresearchwiki.jsc.nasa.gov/index.php?title=Category:All_DRM). The EMCL document may be accessed here (https://humanresearchwiki.jsc.nasa.gov/images/6/62/EMCL_RevC_2013.pdf).

Design Reference Mission	Clinical Priority	Clinical Priority Rationale
<p>Lunar sortie mission</p> <p>Assumptions:</p> <ul style="list-style-type: none"> 4 crewmembers (3 males, 1 female) 14 days total 4 EVAs/ crewmember <u>Level of Care 3</u> 	Shall	Toxic exposure is one of the three major non-medical emergencies that could occur during space flight (along with cabin depressurization and fire). Therefore, medical treatment for this potentially life threatening and/or mission ending scenario shall be manifested..
<p>Lunar outpost mission</p> <p>Assumptions:</p> <ul style="list-style-type: none"> 4 crewmembers (3 males, 1 female) 180 days total 90 EVAs/ crewmember <u>Level of Care 4</u> 	Shall	Toxic exposure is one of the three major non-medical emergencies that could occur during space flight (along with cabin depressurization and fire). Therefore, medical treatment for this potentially life threatening and/or mission ending scenario shall be manifested.
<p>Near-Earth Asteroid (NEA) mission</p> <p>Assumptions:</p> <ul style="list-style-type: none"> 3 crewmembers (2 males, 1 female) 395 days total 30 EVAs/ crewmember <u>Level of Care 5</u> 	Shall	Toxic exposure is one of the three major non-medical emergencies that could occur during space flight (along with cabin depressurization and fire). Therefore, medical treatment for this potentially life threatening and/or mission ending scenario shall be manifested.

Initial Treatment Steps During Space Flight

A link is provided to a prior version of the International Space Station (ISS) Medical Checklist, which outlines the initial diagnostic and treatment steps recommended during space flight for various conditions which may be encountered onboard the ISS. Further diagnostic and treatment procedures beyond the initial steps outlined in the

Medical Checklist are then recommended by the ground-based Flight Surgeon, depending on the clinical scenario. Please note that this version does not represent current diagnostic or treatment capabilities available on the ISS. While more recent versions of this document are not accessible to the general public, the provided version of the checklist can still provide a general sense of how medical conditions are handled in the space flight environment. Medical Checklists will be developed for exploration missions at a later point in time.

Please note this file is over 20 megabytes (MB) in size, and may take a few minutes to fully download.

ISS Medical Checklist (http://www.nasa.gov/centers/johnson/pdf/163533main_ISS_Med_CL.pdf)

Capabilities Needed for Diagnosis

The following is a hypothetical list of capabilities that would be helpful in diagnosis. It does not necessarily represent the current capabilities available onboard current spacecraft or on the ISS, and may include capabilities that are not yet feasible in the space flight environment.

- Vital signs measurement capability (blood pressure, pulse, respiratory rate, temperature, pulse oximetry, as required per the patient's clinical state)
- Auscultation device (such as a stethoscope)
- Ophthalmoscope
- Magnifying glass
- Cardiac [Electrocardiograph (ECG)] monitor
- Clinical laboratory facility (blood gases, chemical analysis, real time chemical monitor)
- Imaging (such as chest X-Ray or ultrasound for inhalation)

Capabilities Needed for Treatment

The following is a hypothetical list of capabilities that would be helpful in treatment. It does not necessarily represent the current capabilities available onboard current spacecraft or on the ISS, and may include capabilities that are not yet feasible in the space flight environment.

- Crew medical restraint system
- Portable Breathing Apparatus (PBA)
- Personal Protective Equipment (PPE) (Protective mask with filter canister, chemical resistant gloves, goggles, Ziploc bag, chemical resistant bag)
- General Treatment
 - Tape, bandages, cotton swabs
 - Ventilator
 - Pharmacy (antihistamines, steroids, charcoal and other chelating agents, etc.)
- Eye Treatment
 - Eyewash capability
 - Ophthalmic anesthetic solution

- Fluorescein strips
- Potential of Hydrogen (pH) strips
- Artificial tears
- Ophthalmic antibiotic solution
- Eye pads
- Skin Treatment
 - Tegaderm dressing
 - Skin cleanser [such as alcohol/Benzalkonium antiseptic (BZK)/iodine]
- Systemic Treatment
 - Intravenous (IV) start and administration kit
 - Intravascular volume replacement (such as IV fluids)
 - IV pump or pressure infuser
- Pulmonary Treatment
 - Bronchodilator inhaler
 - Anti-inflammatory/steroids (oral or injectable)
 - Medication delivery device (such as Carpuject injector)
 - Ambu bag and mask
 - Tongue depressor
 - Intubation kit
 - Ventilator
 - Oxygen (O₂) concentrator

Associated Gap Reports

The NASA Human Research Program (HRP) identifies gaps in knowledge about the health risks associated with human space travel and the ability to mitigate such risks. The overall objective is to identify gaps critical to human space missions and close them through research and development. The gap reports that are applicable to this medical condition are listed below. A link to all of the HRP gaps can be found here (<http://humanresearchroadmap.nasa.gov/Gaps/>).

2.01 - We do not know the quantified health and mission outcomes due to medical events during exploration missions.

2.02 - We do not know how the inclusion of a physician crew medical officer quantitatively impacts clinical outcomes during exploration missions.

3.01 - We do not know the optimal training methods for in-flight medical conditions identified on the Exploration Medical Condition List taking into account the crew medical officer's clinical background. (Closed)

3.03 - We do not know which emerging technologies are suitable for in-flight screening, diagnosis, and treatment during exploration missions.

4.01 - We do not have the capability to provide a guided medical procedure system that integrates with the medical system during exploration missions.

4.02 - We do not have the capability to provide non-invasive medical imaging during exploration missions.

4.04 - We do not have the capability to deliver supplemental oxygen to crew members while minimizing local and cabin oxygen build-up during exploration missions.

4.05 - We do not have the capability to measure laboratory analytes in a minimally invasive manner during exploration missions.

4.09 - We do not have the capability to provide medical suction and fluid containment during exploration missions.

4.12 - We do not have the capability to generate and utilize sterile intravenous fluid from potable water during exploration missions.

4.14 - We do not have the capability to track medical inventory in a manner that integrates securely with the medical system during exploration missions.

4.15 - Lack of medication usage tracking system that includes automatic time stamping and crew identification

4.17 - We do not have the capability to package medications to preserve stability and shelf-life during exploration missions.

4.19 - We do not have the capability to monitor physiological parameters in a minimally invasive manner during exploration missions.

4.21 - We do not have a reusable, single-operator capability to irrigate the eyes during exploration missions.

4.23 - We do not have the capability to auscultate, transmit, and record body sounds during exploration missions.

4.24 - Lack of knowledge regarding the treatment of conditions on the Space Medicine Exploration Medical Condition List in remote, resource poor environments (Closed)

4.27 - We do not have the capability to sterilize medical equipment during exploration missions.

5.01 - We do not have the capability to comprehensively manage medical data during exploration missions.

Other Pertinent Documents

List of Acronyms

B	
BZK	Benzalkonium Antiseptic
D	
DRM	Design Reference Mission
E	
ECG	Electrocardiograph
EMCL	Exploration Medical Condition List
EVA	Extravehicular Activity
H	
HRP	Human Research Program
I	
ISS	International Space Station
IV	Intravenous
M	
MB	Megabyte
N	
NASA	National Aeronautics and Space Administration
NEA	Near Earth Asteroid
O	
O ₂	Oxygen
P	
PBA	Portable Breathing Apparatus
pH	Potential of Hydrogen
PPE	Personal Protective Equipment

U	
U.S.	United States

References

1. Marshburn TH. Acute Care. In: Barratt M, Pool S, editors. Principles of Clinical Medicine for Space Flight. New York: Springer; 2008. p.114-16.
2. International Space Station Integrated Medical Group. Medical Checklist ISS - All Expeditions. Houston: National Aeronautics and Space Administration; 2008.

Last Update

This topic was last updated on 8/13/2014 (Version 2).

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Category: Medical Conditions

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- This page was last modified on 13 August 2014, at 08:47.